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How to apply AI and Automatic into Mission Operation

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It is an innovation trend. So we need to reduce human labor, let Artificial Intelligence (AI) and Automatic help us to make mission operation efficiently, intelligently and automatically. Mission Operation automatically and intelligently include many aspects. Now we design the system by planned assisted operations. The system will on-going automatically by the workflow and plan. We will do "people on duty, no operation" in the future by automatic and intelligence in the future. It includes the improvement of equipment reliability, optimization of the task flow driven scheme, the improvement of automatic operation exception handing strategy and the automatic operation auxiliary means. We hope we can make lights out operation in the future, "no human, no operation".

I. Nomenclature

DAMPE = Dark Matter Particle Explorer
QUESS = Quantum Experiments at Space Scale
HXMT = Hard X-ray Modulation Telescope
SPP = Strategic Priority Program
PLUTO = Procedure Language for Users in Test and Operations
SMOC = Space Science Mission Operation Center
GSS = Space Science Mission Operation Center

II. Introduction

Satellite programs in the 12th Five-year plan(2012-2017) of CAS Strategic Priority Program(SPP) on Space Science are doing well by the mission operation system we built for DAMPE, SJ-10, Quess and HXMT mission.

With spacecraft as the main tools, the space science is aimed to study natural phenomena and the underlying rules in physics, astronomy, chemistry, and life science which occur in solar-terrestrial space, interplanetary space, and even the universe as a whole. It is a highly integrated and inter-disciplinary field.

CAS Strategic Priority Program(SPP) on Space Science started on January 11,2011. The main goal is dedicating to deepening our understanding of the universe and planets, seeking new discoveries and breakthroughs in space science via the implementation of both independent and cooperative space science mission.

Satellite program in the 12th Five-tear plan: HXMT(Hard X-ray Modulation Telescope) study the law of physics under extreme conditions and the properties of black hole; Quess(Quantum Experiments at Space Scale) complete inspection of quantum mechanics; DAMPE(Dark Matter Particle Explorer) seek evidence of dark matter annihilation; SJ-10 study the law of physical movements and life activities in space environment.

There are 6 systems in the space science project, the Satellite system, Launching sites system, Control system, Rocket system, scientific application system and the Ground support system. We build the ground support system in Huai Rou distinct, Beijing. Our responsibilities include mission planning and scheduling, payload operations, data receiving, archive all data products, and long-term data service to science data user community. Now in the next Five-year plan, we have to support other 6 missions. It is an innovation trend. So we need to reduce human labor, let Artificial Intelligence (AI) and Automatic help us to make mission operation efficiently, intelligently and automatically.

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III. Mission Operation Automatically and Intelligently

With the deepening of space exploration mission and the ever-growing number of spacecraft, payload and other devices, the operation center has to be faster and richer data processing capability for automatic operations with support and it also requires flexible system reconfiguration features. Software of the ground support system are moving forward to the intelligence, automation and standardization. In order to make the system automatic and intelligent, we need a standardized procedure language.

The PLUTO specification is a recommendation standard about ground testing and in-orbit operations which is released by ESA. It is a standard for testing and operating procedures in space engineering. It is mainly applied to ground test, in-orbit test and in-orbit control of space vehicle and payload. Due to PLUTO's flexible language structure, rich logical definition and standardized process description, the language is increasingly used in various space ground systems.

IV. Significance

Scientific satellite operation management is a closed loop process combining upward control and download monitoring. Traditional satellite operation in each key step which require the participation of people, including mission planning, generating commands, payload monitoring, especially in the processing of abnormal case, which need more personnel manual intervention for processing.

Multiple satellite on-orbit operation at the same time, more space science mission orbiting platform is needed in the development of automation control technology, effectively improve the operation ability of the system, reduce human intervention to produce the hidden trouble of the error. Need a scientific satellite uplink control automation technology and method, and according to the business in the individual service requirements in terms of self-learning, generated automatically run rules, make the system have the value-chain and pluggable support, hot plug and dynamic support, automation and parallel support, make the system flexible, agile response ability and good characteristics of extensible ability. On the one hand, it can improve the automatic level of the original system; On the other hand, we can quickly build new system capabilities to provide operational management capabilities for new satellites.

Analysis of space science satellite operation management system task nodes, and associated characteristics of the process, business model, in the form of service flow, realize automatic operation of the scientific satellite uplink control, real-time process track record task monitoring information; The semantic model is used to define the function, task and work mode of scientific satellite operation, and the effective operation and reasonable control of the task flow node are realized through semantic analysis. Under the service-oriented architecture, the process is defined and interpreted, and a service-oriented workflow architecture is built. The business functions are refined and designed in the form of services. As far as possible, the artificial intervention control of the space science satellite operation management system is minimized, so as to improve the autonomous operation ability of the system and reduce the hidden trouble of human intervention.

Each node in the service flow are in the process of a service, the control of process management, based on process language respectively responsible for handling shipment control process of single exploration program, single star orbit calculation, single mission planning, single task dynamic adjustment, multiple collaborative task planning, single star plans, single instructions generated, the single inversion, a lot of link such as single star sends instructions, in addition to various service based on business needs, need to users in special circumstances to the intervention of the system for statistical analysis, found the regularity of human intervention, for a variety of business rules for self-learning, can reduce the number of user intervention in the process of transport control, improve the operation ability of the system, the automation level of system can give full play to.

A. Automatic mode analysis of mission operation

Relying on the SPP, in the center of the National Space Science Center, we set up the scientific mission operation center by the framework of "platform plug-ins" design, supporting the multi-tasking driven workflow satellite mission work platform. We have the ability of comprehensive planning and planning, command generation and dispatch, downlink data processing and monitoring.

We study the automation requirements, analyze the steps of the automation operation, and the risks that the automation may bring to the operation.

B. The applicability of process language

Through the analysis of the process language used for mission operation at home and abroad, we choose PLUTO as the standard for automatic control. The language support set breakpoints, step, automatically, provide regular

control structure, programming kit and database access interface, able to perform syntax checking, and has good human –computer interaction interface.

C. Automatic business content

Uplink automation control: From detection plan submitted to sending the tele-commands to the control system, according to the use of operation, support of fully automatic mode and manual intervention in a way that all kinds of operation and flow, finally complete the unattended uplink control.

Satellite payload monitoring automation: to establish a satellite payload interpretation knowledge base, realize parameter monitoring automatically, to strengthen the comprehensive interpretation ability, instead of artificial judgment. Also through the real=time communication means to send abnormal warning, such as Email, short message, to monitor unattended. In another aspect, for the payload and system data monitoring, now we only have website monitoring and application version. But the time trend now, system just by IPAD, Phone is indispensable. In that way, no matter where the operator is, we can be on duty 24 hour 7days a week. If there is abnormal, the system will send a message and make a call to the operator in charge, which will save a lot of time and energy.

The data quality analysis and abnormal judgment: design quality analysis engine and traverse various data of anomaly detection and disposal mode, enables the system to intelligently identify abnormal data, and automatic alarm, trigger backup data process. In order to improve the efficiency of data anomaly analysis and resolution, it is necessary to focus on and review the situation.

Satellite emergency disposal automatic: to solve the problem of data loss and operation status of payload, according to the emergency response plans, automatic generation of sequestration or load control instruction, reel-time to send, meet the demand of the satellite data production.

Besides, we will work on the failure diagnosis by AI. Intelligent fault diagnosis technology is the artificial intelligence technology in the diagnosis of the product from a reference, it with artificial intelligence, especially expert system, the development of knowledge engineering and artificial neural network and continuous development. By the help of AI, the operation system will diagnose the failure automatically by the mass data and operation experience.

V. Technical solution

The operation work mode analysis mainly for space science operation, analyze the input, output, timeline and influence domain, is a basis for automation implementation.

Process language as a breakthrough point, the research on space science satellite operation direct applicability, try to follow the standardization of ECSS (European space cooperation organization).Research on space description method of system model, process execution flow language, the interaction between space system models and scripts, including the 3 stages of lexical, grammatical and semantic analysis.

Research uplink operation control automation, satellite payload parameter monitoring automation, data quality analysis and abnormal discriminant automation and satellite service emergency disposal automation this four business content automation implementation route, and by using machine learning and data mining technology, to carry out the experiments, validated by this topic research and technological achievements.

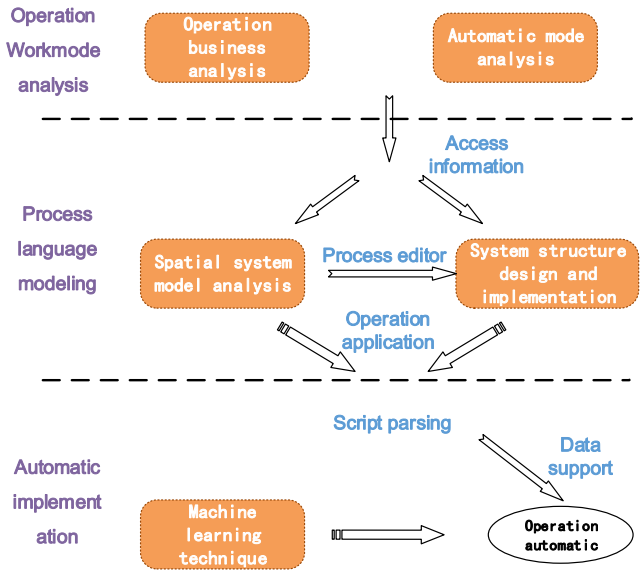

Fig. 1 Proposal and implementation.

VI. Conclusion

Satellite programs in the 13th Five-year plan (2016-2020) of CAS Strategic Priority Program (SPP)on Space Science have a remarkable feature of highly cooperation. SVOM (Space-based multi-band astronomical Variable Objects Monitor) and SMILE (Solar wind - magnetosphere interaction panoramic imaging satellite program) are two satellites by cooperation with CNES and ESA. There will be a lot of coordination and communication work by the two sides during the generating scientific work plan and make fight control decisions. So an automatic and intelligent is particularly important for the operation system. Because of the jet-lag and language are different, an automatic and intelligent system is in urgent need. We hope we can make lights out operation in the future, “no human, and no operation”.

The procedural scripting language has been applied to the remote operation of spacecraft, but in the orbit management of space science satellites, it is a new attempt and innovative. How to save the cost of operation and control, avoid human error, improve the reliability of the system, improve the efficiency of operation and control, provide the flexibility of operation and control, and liberate the operation and control personnel. However, in the domestic and foreign related data, there are few reports based on the actual measurement data and satellite's automatic control technology. It's innovative.

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